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# CLIMATE FOR AGRICULTURAL LAND CLASSIFICATION IN ENGLAND AND WALES

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## 1. Introduction

The Agrometeorology Department of the Meteorological Office were tasked by MAFF with mapping first, the accumulated temperature (T*) above 0°C from January to June inclusive and second, the maximum Potential Soil Moisture Deficit (PSMD) for Agricultural Land Classification purposes. The mapping of T* was made easier by reducing all data to Mean Sea Level using a correction factor of 0.6°C per 100 m but data from some stations, eg Manchester Airport, had to be ignored because they were not compatible with the majority of data which were for exposed locations away from man-made heat sources. The mapping of Max PSMD was impossible however, because the geographical variations were on a smaller scale than the distance between data points and no unique relationship could be determined between Max PSMD and topographic height, Annual Average Rainfall, etc. The network of 82 stations in England and 11 in Wales are in varied locations such as towns, open countryside, seaside resorts, parks, a forest clearing and airfields. The map showing the true pattern of Max PSMD (or PE) cannot be "decoded" from the "noise" introduced by the many types of station. Another contributory factor may be that two of the terms which contribute most to PE in summer, ie temperature and sunshine, vary in opposite directions which tends to smooth out much of the large scale geographical differences. In summer temperature is usually lower on the coast but there is more sunshine there. Furthermore there are very few inland stations in South West England and in Wales. The difficulties with mapping Max PSMD have led to the following review of the main climatic factors affecting agriculture. Summer rainfall is introduced as the likely substitute for Max PSMD without referring to the obvious advantages that summer rainfall can be accurately mapped and is easily understood.

## 2. Climate

The main climatic factors affecting the achievement of maximum crop production in England and Wales are:-

a) Temperature in the first half of the year for maximising leaf growth and photosynthesis.
b) Excess rainfall in the summer half year, April to September inclusive, affecting trafficability and workability of the land.
c) Excess rainfall in the winter half year reducing period of workability and causing anaerobic growing conditions.
d) Drought stress due to low summer rainfall.
e) Strong winds causing crop stress and soil erosion.
f) Heavy rainfall damaging the crops and causing erosion of the land.

## 3. Temperature

Recent studies by Biscoe and Gallagher (1978) have shown that leaf growth for cereals is well correlated with accumulated temperature above 0°C. On the other hand Waring and Cooper (1971) have shown that high temperature in late summer can be detrimental to a wide range of crops. Therefore accumulated temperature above 0°C from January to June inclusive is a good guide to the number of leaves grown and hence the amount of radiation intercepted for photosynthesis. The geographical variation of annual radiation falling on a flat surface is less than 10% across much of England and Wales and this is much less than the geographical variation of accumulated temperature. The aspect, ie slope of the land and its direction of fall, may affect the radiation more significantly than the geographical location and this should be allowed for in particular field studies.

Numerous researchers, including Penman (1962), Hanks (1974), Doyle and Fisher (1979) and Green, Vaidyanathan and Hough (1983), have shown that during the main growing phase of a wide range of crops there is a close relationship between dry matter production and potential evapotranspiration (PE); here the PE includes transpiration and evaporation.

The PE is a theoretical parameter which is computed assuming no restriction of transpiration through lack of water. For a specified crop and soil type the PE is chiefly dependent on the temperature, radiation, humidity and the wind. The geographical variations of average radiation are relatively small, especially in summer. Low humidity is closely related to the afternoon maximum temperature and away from the coast the humidity is related to the mean temperature. Therefore for many purposes, including producing a map of the geographical variation of the available energy factor for agricultural land classification purposes, the accumulated temperature above 0°C, January to June inclusive, is probably the best single parameter apart from PE. Accumulated temperature can be mapped more accurately than PE, however, because reliable radiation and wind data are sparse and their geographical variation is complex.
Strong winds cause greater stress as well as greater PE and the wind factor is considered later.

## 4. Excess Rainfall in Summer

The average annual rainfall (AAR) varies from about 500 mm (20") in the dryest parts of South East England to over 4,000 mm (160") in the wettest parts of North Wales and Cumbria. The rainfall is almost equally divided between the summer and winter seasons but soil moisture deficit (SMD) generally increases from zero in winter to over 50 mm in most areas by July, and to over 100 mm in the dryest places. However, in some areas, eg much of Wales, the Pennines and Cumbria, the evaporation plus transpiration rarely exceeds the rainfall by very much even in the summer.

Areas with good soil drying potential, ie high evaporation and low rainfall in summer, have a distinct advantage over areas slow to dry out because the soil warms up more quickly and trafficability improves. A reasonably dry climate at harvest time and seed bed preparation time is beneficial although some rainfall is essential for good germination. In many areas irrigation is essential for economic yields from crops such as potatoes and sugar beet but this is not considered a climatic restriction for ALC purposes. The likelihood of droughtiness through low available water capacity of the soil coupled with low summer rainfall is considered later.

It follows from above that a key parameter for assessing soil drying conditions is the accumulated value of "PE minus rainfall" which is called the "potential soil moisture deficit". If the beneficial effects of large values of PE are indirectly allowed for through the accumulated temperature factor then the remaining key parameter is the summer rainfall. In most areas, even in the dryest parts, the soil is at or near field capacity in March and it is the drying conditions from April onwards which are important. The Meteorological Office have produced a map of average summer rainfall (1941-70) based on over 1,000 stations with 30 years of record.

## 5. Excess Winter Rainfall

Excess winter rainfall effects trafficability, causes anaerobic soil conditions and nitrogen losses just as summer rainfall can, however, the land returns to field capacity earlier (August or September) or later (November or December) depending on the rainfall. In the UK the places with high summer rainfall invariably have high values of winter rainfall also and the land slow to dry out in early summer is the same land which is quick to return to field capacity in the late summer, therefore the inclusion of the winter rainfall as an additional parameter for ALC purposes is probably not justified because it is so closely related to the summer rainfall and their effects are complementary. However, for drainage design purposes Excess Winter Rainfall is very important, Smith and Trafford (1976).

## 6. Drought Stress

Drought stress can significantly effect yields especially those of shallow rooting crops such as potatoes. The lack of water can be overcome by irrigation but some soils are more prone to drought stress than others simply because of the texture and depth of the soil affecting the available water capacity (AWC). There may be large variations of AWC over short distances, especially in the light soils, whilst the corresponding changes of the average annual rainfall or summer rainfall will be very small. The key factor is the AWC and the climatic contribution may be very simple and probably still serve its purpose. Therefore a possible parameter for drought stress is summer rainfall plus AWC for grassland as the rainfall contributes to the growth all summer long. For winter cereals, however, a better parameter is

$$\frac{\text{Summer Rainfall}}{2} + \text{AWC}$$

because the rainfall in the second half of summer contributes little and almost certainly interferes with harvesting and grain drying operations.

If the geographical variation of PE could be accurately mapped, then the best parameter for relating to agricultural droughtiness probably is

$$F.\ (\text{Summer Rainfall}) + \text{AWC} - PE^*$$

where $PE^*$ is the potential evaporation for the fraction F of the summer up to the time of senescence of the particular crop. This may be rewritten as

$$\text{AWC} - PSMD^*$$

where $PSMD^*$ is the accumulated potential soil moisture deficit up to the time of senescence of the particular crop and some allowance is made for the period from April onwards when the crop has not achieved full ground cover. This scheme has been fully described by Thomasson (1979).

## 7. Wind

Damaging wind may result from the down-drought of thunderstorms but the longer lasting strong winds are usually associated with depressions moving eastwards across or just to the north of the British Isles. The areas of England and Wales most affected by strong winds are the hills and coasts of western and northern regions. The coastal fringe in the south and east of England has more frequent strong winds than places further inland.

Like rainfall average windspeeds generally increase with altitude and proximity to the west coast, however, for wind erosion the light soils in the dryer eastern regions of England are the ones most at risk and the geographical variation of the frequency of strong winds is not so important. Wind erosion is affected by exposure too because a flat treeless landscape provides less frictional retardation of the wind, Davies and Harrod (1970).

## 8. Heavy Rainfall

Heavy rainfall in summer can cause serious losses in cereal crops through lodging especially after ear emergence and with the longer straw varieties. In many parts of the country August is one of the wettest months of the year and heavy rainstorms are usually the main contributing factor. The central and southern parts of England are more at risk from heavy rainstorms than other regions, eg summer storms account for about 40% of summer rainfall in London but only 15% of summer rainfall at Aberporth on the west coast of Wales.

It is often overlooked that soil erosion caused by heavy rainfall can be more damaging than wind erosion although the effects are usually more localised, eg a landslide at a gulley. This can occur at any time of the year but it is more likely to happen in the late winter - early spring period when the land is already at field capacity and is more likely on sloping land.

The average frequencies of monthly, weekly, daily or hourly rainfalls of any intensity for any location can be obtained from your Regional Agro-Met Office.

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